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Linear Modelling for Sustainable Transportation System

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Abstract: In this paper, the four principles of sustainability and the limitations of high and low quality fuel energy have been considered to simulate the transportation systems. The environmental impacts of transportation systems are related with populations and technology which all lead to unsustainable impact on environment. Five means of transportation systems have been considered in this model, those transportations systems are bicycle, water, taxi, bus and metro. The resulting ecological footprint effect expressed in Anti-Sustainable Impact is being used to reflect those means of transport on environment. A simplified approach to those means is represented in the derived linear model by Bicycle Sustainable Unit BSU. The equivalent effects of different transportation systems on environment are represented graphically. Guidelines for such results are considered to optimize the sustainability of transportations. Conclusive remarks have been drawn accordingly to achieve safe and sustainable guidelines to be implemented in future traffic and transportation systems and their deployments in cities.

Keywords: Anti-Sustainability, Transportation, Environmental Impact, Modeling, Sustainability, Mathematical, Ecology, Ecological Footprint, Carbon Footprint, Traffic Systems

1. Introduction

In the later years of the second part of the last century, the term sustainability has taken an important space in development, operations of systems and other aspects of applications. That has been done, to reduce the pollution that results and to preserve environment. The transportation sector is of no doubt constitutes a noticeable source of pollutions and energy usage, this sector represents approximately 40% of energy consumption (Hassoon, 2016). The sustainability depicts how to preserve bio-diversified and productive systems all the way round. For us as human population sustainability means the ability to maintain proper living in the long run via preserving the natural environment from degradation and the ideal usage of the earth resources and the ability of the earth to absorb the waste byproducts (Miller & Spoolman, 2012).

The ever increasing population, the immigration from countryside to cities, the usage of oil to boost development and the resulting environmental pollution, the increasing demand for energy and the alarming environmental degradation all together led to pursue this study.

The type of transportation used in a given place will in no doubt influence the degree of affluence in energy usage by a given population. (Miller & Spoolman, 2012) quoted a relation which depicts proportionality between the environmental impact is linearly related with the people, their degree of

affluence and the technology being used. (Yevdokimov & Mao, 2004) developed their implicit model through interaction introduced transportation system in interactive links between society, environment and economy (Gilbert, Irwin & Hollingsworth, 2002). Sustainable Transportation Performance Indicators (STPI) introduced 14 indices for sustainable transportation, all related to the effects and limitations of the transportations systems on different aspects of energy usage, emission, people movements, land usage by people and people movement in Canada (Richard, Irwin, Hollingsworth & Blois, 2002). The anti-environmental reactions to littering survey was done by Ma in 2016. The Dow Jones Sustainability Indices (DJSI) launched in 1999, are a family of indices evaluating the sustainability performance of the largest 2,500 companies listed on the Dow Jones Global Total Stock Market Index. Assessing issues such as corporate governance, risk management, branding, and climate change mitigation, supply chain standards and labor practices. The trend is to reject companies that do not operate in a sustainable and ethical manner. It includes general as well as industry-specific sustainability criteria for each of the 58 sectors defined according to the Industry Classification Benchmark (ICB) (Dow Jones INDEX, 1999).

Once again, all interpretations leave implicit approach to describe the highly complex domains of environmental sustainability. In the current model it is intended to simplify linearly a comparative sustainability and anti-sustainability reactions to the usage of transportation systems. The priority is getting the lowest anti-sustainability. The developed linear model, takes into consideration, the energy quality that influence sustainable transportation system. A bicycle is considered of the upper end of sustainability and the most polluting energy consuming transporting system at the lower end of scale of 5. The derived mathematical model is simulated on five transportation systems all shows their anti-sustainable environmental impact in simplified approach. This simplified linear model can be developed in later stage to further implementations in non-linear complex environmental processes.

2. A Study Approach for the Model

In this model, five systems of transportation systems are being considered, they are bicycle, water transport, taxi, bus and metro. To simplify the effect and impact of those transporting systems on environment a (1 to 5) scale is being considered, this scale is introduced based on the degree of high quality energy used in driving the transportation system. Where 5 is classified as of sustainable impact, because of the fact low quality energy is utilized (the solar capital), on the other hand, Metro system reflects using very high quality energy usage, in this system oil energy is passed through various processes starting from the extraction, refining transportation, combustion, power generation then distribution to be reached to metro as high quality energy to provide electricity to drive the metro system; thus more bad effects on the environment are experienced. The following table depicts the rank of the high quality energy used in five systems, metro, bus, taxi, water and bicycle respectively.

It is a common practice to evaluate any product or process scaling probability from 1 to 5, such that the worse is a metro and the best is the bike. As shown in the (Table 1).

Table 1: Environmental Impacts for Different transportation Systems

	Degree of Sustainability	System
Very Bad Impact	1	Metro
Bad Impact	2	Bus
Medium Impact	3	Taxi
Acceptable Impact	4	Water
Sustainable Impact	5	Bicycle

The driving energy and the transport impact affecting the environment and infra-structure and its availability and whether it is high or low quality energy are all considered in this methodology.

Generally speaking, in constructing any model of any transportation system, one has to ask whether this transportation system is on a sustainable path. In this case an answer for the four principles of sustainability. The solar capital, the chemical cycling, the bio-diversities and the population growth are all to be considered (Miller & Spoolman, 2012). Another important consideration is the engineering, economical and feasibility of providing the driving energy to the transporting system, this categorized as high or low quality energy and high or low quality matter both give different concepts in its availability and impact on environment and society and of course on economy, all in all, it is more practical to evaluate the environmental impact on scale of values (1 to 5) as shown in table 1 above. In this table, the number 5 is allocated to bicycle system which is absolutely environment friendly and directly related to solar capital and the other end is metro which is normally driven by high quality energy. The degree of Sustainability for different transportations systems are as shown by (Figure 1).

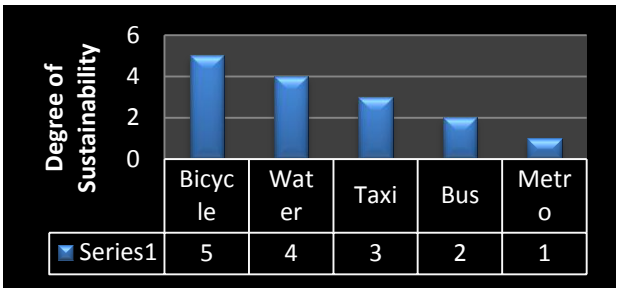

Figure 1: Depicts the Degree of Sustainability for Different Transportation Systems

The model depicts any of the above systems which leaves less damage to the environment is mapped at the upper parts of the scale. While, any notion that leaves unwanted feedback on the environment is placed at the lower end of the scale, in other word less sustainable.

The bicycle sustainable impact BSI is defined by:

$$BSI = \frac{nI}{5} \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The Bike-Impact BSI for all transportation systems is plotted as shown in (Figure 2).

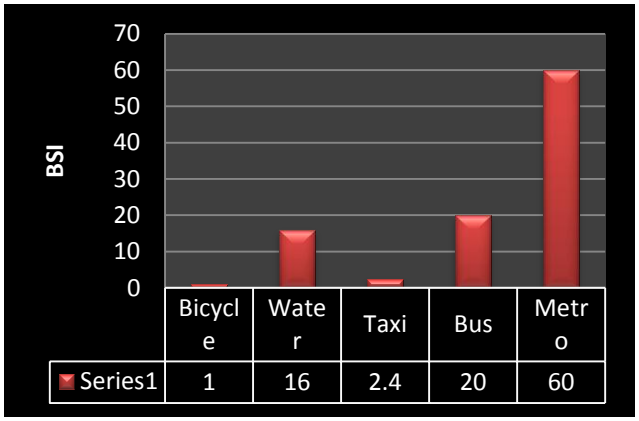

Figure 2: Shows the Bike-Units Environmental Impacts

The Anti-Sustainable Impact ASI is then found by subtracting one from the Bike-Sustainable Impact BSI and expressed in equation (2) as follows:

$$ASI = \frac{nI}{5} - 1 \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The Anti-Sustainability Impacts for different transportation system is plotted in (Figure 3).

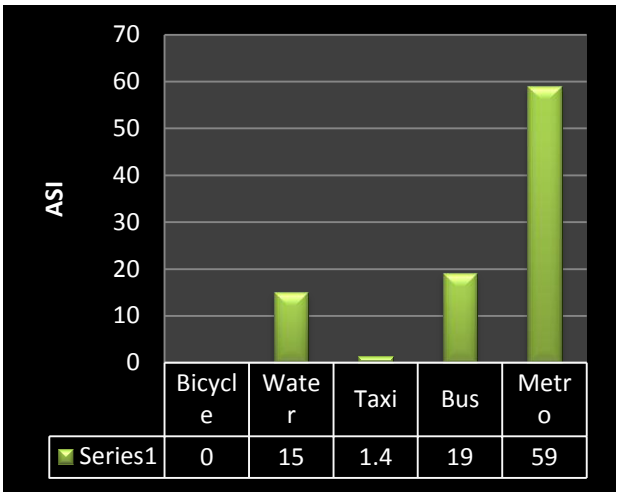

Figure 3: Shows the Variation of Anti-Sustainable Impact with Different Transportation Systems

3. Results and Discussion

All environmental processes are never linear; the whole environmental system is almost complex system. There many factors needed to be considered, the author will be able to develop such system in later stage of the research.

Modeling of sustainable Transportation systems on system is considered as the most complex way to fit all factors involved, which is because of nonlinearity in nature where statistics and probability are the prime limiting factors for mathematical model. It is thought to simplify an approach to deal with transportation system in a subjective way, where population or social factor, economic, and environmentally related accessibility, energy availability and quality are all considered.

Here (Figure 1) shows the suggested degree of sustainability based on 1 to 5. The column chart states the environmental impact exposed by the transportation system as it is being independent identity in any city environment. (Figure 2) takes into consideration the carrying capacity of the systems n. It is practically known that the carrying capacity of the five systems are n=1, 20,4,50 and 300 individuals respectively. Thus the Bike-Sustainable Impact BSI given by equation (2) is as shown in (Figure 2). The subtraction of the sustainable system represented by the bicycle from every BSI in (Figure 2); this will result of zero ASI by the bicycle system and the rest are clearly shown in (Figure 3). It is then concluded by this figure to counter act the deterioration of the environment due to the positive feedback on the environment, it is necessary to reduce those peaks of the histogram in (Figure 3).

4. Conclusion

The following can be drawn out of this paper:

a- A simplified mathematical model has been constructed to mitigate linearly the commonly known transportation systems.
b- The paper suggests incorporating the Anti-Sustainability concept to reduce the ecological footprint resulting from using the different types of transportation system.
c- The model suggests clearly that the Anti-Sustainability effect due to bicycle as transport system is zero.
d- The model suggests new means to measure sustainability in transportation system s which is Bike-Sustainable Impact BSI.

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